# PERFORMANCE TESTS ON A FRICTIONAL HEATING DEVICE MANUFACTURED BY WESTERN ENERGY CORPORATION

by

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## FOREWORD

The performance of frictional furnaces is a matter of public interest. These tests have been conducted and funded by Saskatchewan Research Council in the interests of providing the public with an unbiased evaluation of this new type of furnace. Such tests should not be construed as an endorsement or non-endorsement of the product by Saskatchewan Research Council.

This report describes performance tests conducted by Saskatchewan Research Council on a residential space heat system manufactured by

Western Energy Corporation
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S4P 1Y6

The design is fairly typical of the 'frictional furnace' type that has appeared on the market in the last two years. Basically, the system uses a large horsepower electrical motor to drive a device that generates heat by friction. A number of units, of United States manufacture, are now being sold in Saskatchewan. In many cases the manufacturers are claiming that the devices have an efficiency greater than 100%. If this is true, then such devices would be of considerable benefit in rural Saskatchewan in the transition from oil-heating to electrical-heating systems. However, there are good scientific reasons for doubting that these devices can achieve an efficiency greater than 100%.

Western Energy Corporation has built a production prototype, and has submitted this to Saskatchewan Research Council for tests. The company is anxious to have an unbiased efficiency test on their product before determining their production strategy. The results of such tests will obviously be of considerable interest to the public. Accordingly, and with the full agreement of Western Energy Corporation, the results of the tests are non-confidential.

The tests were conducted in two parts:

- The furnace was tested for thermal performance as delivered from the manufacturer.
- The furnace bonnet was sealed carefully with duct tape on all joints and openings, then covered with 2" foil backed fibre glass insulation. The test was then repeated.

The furnace was set up as shown in Fig. 1. To determine the thermal performance of the furnace, volume flow rate and temperature rise of air through the furnace was measured. Pitot tube traverses were employed at a minimum distance of 7.5 pipe diameters away from any disturbances to measure air velocity. The amount of air leakage through the furnace bonnet was determined by the differences in inlet and outlet air flow measurements.

The inlet air temperature was measured by a thermocouple located after the furnace air filter, while the outlet temperature was measured with five thermocouples set up across the furnace opening.

The electrical power input to the furnace was integrated by a standard utilities demand meter. The 3 hp. motor steady state draw current was indicated by the built-in ampere meter and checked by a digital clamp-on current probe. Starting surge current of the motor was logged on the digital clamp-on current probe.

The furnace was wired and started up without running the 3 hp. friction motor to determine heat dissipation from the blower motor. All temperatures were scanned by the data logger every 5 minutes. The furnace was run for several hours until it came to steady state condition (Thermal equilibrium). Steady state air delivery was recorded. From the inlet and outlet air flow difference, it was clear that the furnace bonnet was leaking quite badly. Effort was directed to seal and insulate the furnace to ensure meaningful data. The 3 hp. friction motor was turned on after blower motor electrical consumption and heat dissipation had been determined. All temperatures were monitored continuously and air flow rate was checked at the beginning and end of each test run. Several complete test runs were conducted. A summary of instrumentation and measurement accuracies is given in Table 1.

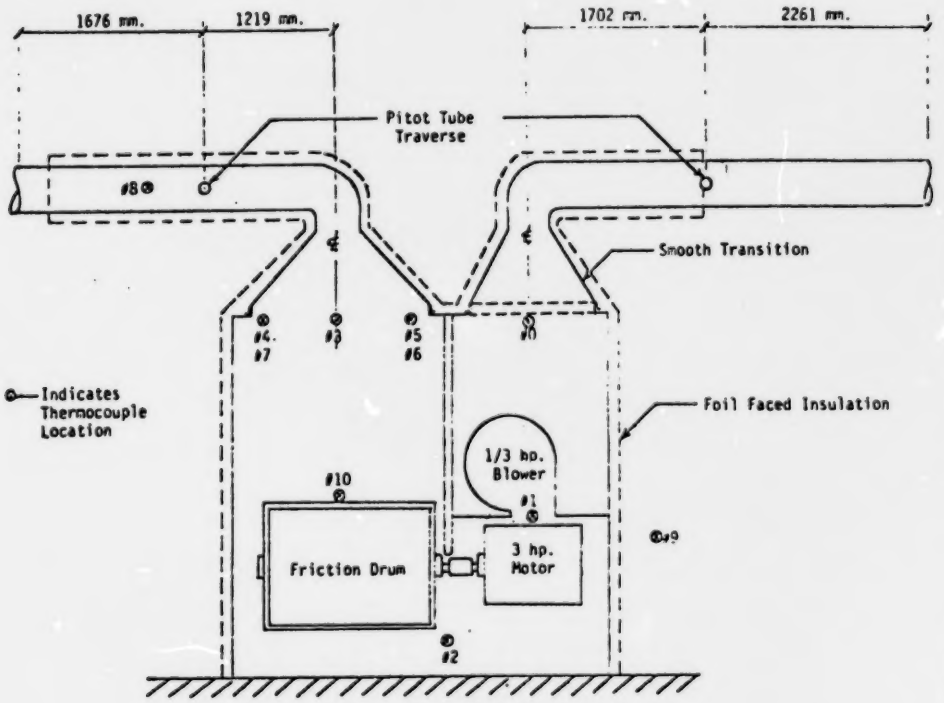



Figure 1. TEST SET UP SCHEMATIC

The energy input rate (BTU/hr.) was determined by the following equation:

$$\dot{Q}_{in} = 3414 \frac{BTU}{Kwh} (Kwh_2 - Kwh_1)/\Delta hr. \quad (1)$$

where $\dot{Q}_{in}$ = Electrical energy input rate (BTU/hr)

$Kwh_1$ = Kwh meter reading at the beginning of test run (Kwh)

$Kwh_2$ = Kwh meter reading at the end of test run (Kwh)

$\Delta hr.$ = Time spent of test run (hr)

The gross heat output rate was calculated as follows:

$$\dot{Q}_g = \dot{M}\, Cp\, \Delta T \quad (2)$$

where $\dot{Q}_g$ = gross heat output rate (BTU/hr.)

$\dot{M}$ = mass flow rate of air (Ibm/hr.)

Cp - specific heat of air (BTU/Ibm $^{o}F$)

$\Delta T$ = temperature rise of air ($^{o}F$)

The net heat output from the friction motor and drum was computed as:

$$\dot{Q}_{net} = \dot{Q}_g - \dot{Q}_b \quad (3)$$

where $\dot{Q}_{net}$ = net heat output rate from the friction motor and drum

$\dot{Q}_b$ = heat contribution by the blower motor

The overall furnace efficien was calculated as:

$$N = \frac{\dot{Q}_g}{\dot{Q}_{in}} \quad (4)$$

where N = overall furnace efficiency

| Instrumentation List | Measurement | Remarks |
|---|---|---|
| 1 Fluke 2240 B Data logger | Thermocouples recorder | ·1ºC resolution |
| 10 Type 'T', copper-constantan thermocouples | Air temperature rise at various locations | ±.5ºC accuracy |
| 1 Airflow Developement Mk.5 inclined manometer | Air velocity head indicator | 0 - 0.5 in. WG<br>.001 in. resolution<br>1 - 5% accuracy |
| 1 Dwyer standard pitot tube | Air velocity head sensor | |
| 1 Keithley digital current probe | Motor surge and steady state current | |
| 1 Sanqamo, Type CJA Kwh power meter | Electrical power consumption | |

Table 1. Summary of Instrumentation

A schematic diagram of the test furnace is shown in Fig. 1. Two smooth transitions (see Fig. 2) were built for the inlet and outlet openings of the furnace to reduce the size from 38.0 cm x 38.5 cm and 51.5 cm x 38.5 cm respectively to 15.2 cm diameter ducts. A total length of 7 meters and two 90° elbows of 15.2 cm diameter duct were coupled to the inlet and outlet transitions. All joints on the transition adaptors and duct work were taped to avoid additional leakage, but excluding the furnace bonnet in the first part of the test. The furnace bonnet was sealed and insulated in the second part of the test.

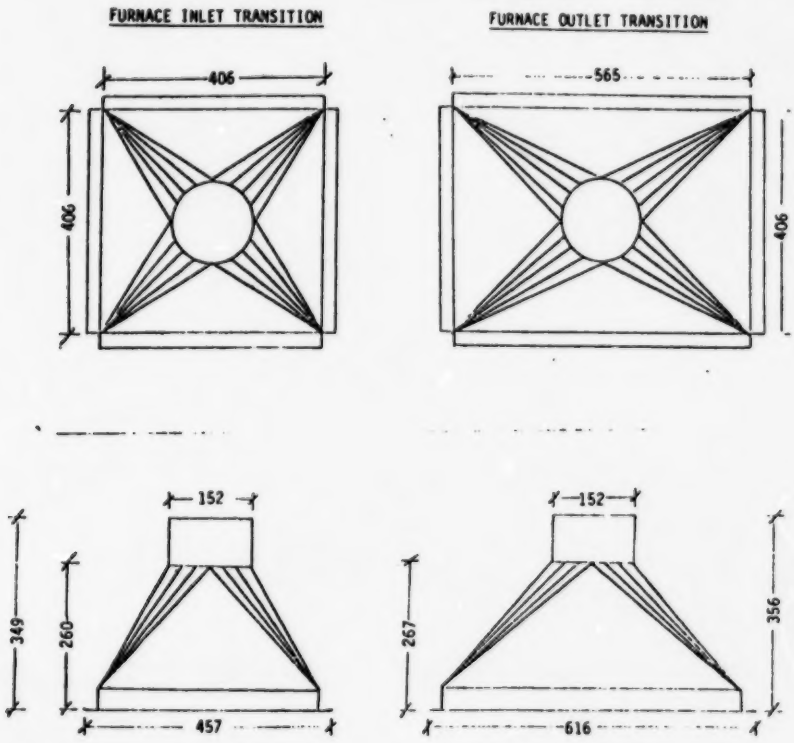
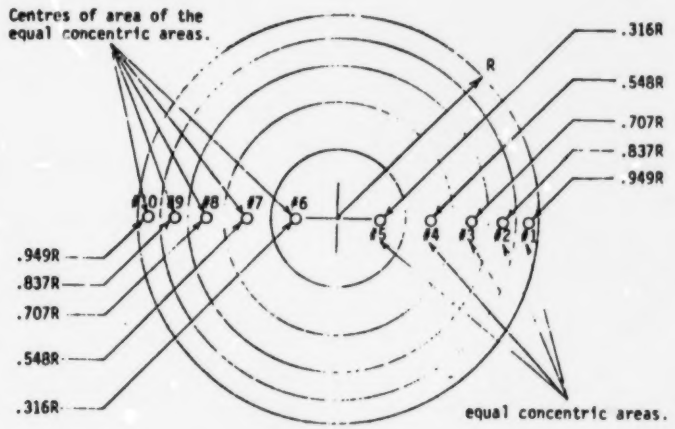



Figure 2. INLET OUTLET TRANSITION

## 4.1 Air flow rate measurement

4.1.1 Furnace tested as delivered. A 10-point pitot tube traverse was used to determine the flow rate (Fig. 3). The data are given in Table 2 and are summarized in Table 3. A sample calculation is given in Appendix I.

The discrepancy between the inlet and outlet mass flow rate indicates a significant leakage through the furnace bonnet on the blower suction portion, and this prevented any precise measurement of thermal performance in this part of the tests.




Pitot tube stations indicated by
10 points traverse includes #1 to #10.
6 points traverse includes #2, #3, #4, #7, #8, and #9.

Figure 3. PITOT TUBE TRAVERSE FOR ROUND DUCT

4.1.2 Furnace was sealed and insulated. Fully developed turbulent flows were obtained in the 6" diameter inlet and outlet ducts. Velocity pressure was measured with a 6-points traverse as shown in Fig. 3. Table 4 gives the raw data. The average air flow rate and mass flow rate were calculated (see Appendix I) and summarized in Table 5. The agreement between inlet and outlet flow rates is good. It confirmed that the unit was sealed effectively, making it possible to conduct accurate thermal performance tests.

Table 2. AIR FLOW MEASUREMENT RAW DATA (PART 1)

| LOCATION | VELOCITY HEAD IN. OF WATER (MM. OF WATER) | | | | | | | | | | TEMP. OF AIR($^{o}$C) | ATMOSPHERIC PRESSURE (BAR) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # 1 | # 2 | # 3 | # 4 | # 5 | # 6 | # 7 | # 8 | # 9 | #10 | | |
| INLET DUCT | .082 (2.083) | .082 (2.083) | .093 (2.362) | .086 (2.184) | .097 (2.464) | .093 (2.362) | .097 (2.464) | .090 (2.286) | .093 (2.362) | .090 (2.286) | 22.3 | .95 |
| OUTLET DUCT | .105 (2.667) | .109 (2.769) | .114 (2.896) | .120 (3.048) | .124 (3.150) | .128 (3.251) | .128 (3.251) | .124 (3.150) | .121 (3.073) | .112 (2.845) | 44.4 | .95 |

Table 3. SUMMARY RESULTS FOR AIR FLOW MEASUREMENT (PART 1)

| | AVERAGE AIR FLOW RATE CFM ($m^3$/sec) | AVERAGE MASS FLOW RATE lb/min.(Kg/sec) |
|---|---|---|
| INLET DUCT | 236.16 (.112) | 17.67 (.134) |
| OUTLET DUCT | 282.0 (.133) | 19.46 (.147) |

Table 4. AIR FLOW MEASUREMENT RAW DATA

| LOCATION | VELOCITY HEAD, IN. OF WATER (MM. OF WATER) | | | | | | TEMP. OF AIR($^{o}$C) | ATMOSPHERIC PRESSURE (BAR) |
|---|---|---|---|---|---|---|---|---|
| | # 2 | # 3 | # 4 | # 7 | # 8 | # 9 | | |
| INLET DUCT | .070 (1.778) | .092 (2.337) | .110 (2.794) | .094 (2.388) | .092 (2.337) | .072 (1.829) | 22 | .95 |
| OUTLET DUCT | .085 (2.159) | .105 (2.667) | .115 (2.921) | .113 (2.870) | .095 (2.413) | .082 (2.083) | 45 | .95 |

Table 5. SUMMARY RESULTS FOR AIR FLOW MEASUREMENT

| | AVERAGE AIR FLOW RATE CFM,($m^3$/sec) | AVERAGE MASS FLOW RATE lb/min.(Kg/sec) |
|---|---|---|
| INLET DUCT | 233.5 (.110) | 17.47 (.132) |
| OUTLET DUCT | 257.6 (.122) | 17.77 (.135) |

## 4.2 Blower motor heat contribution and steady state power

The raw data are presented in Table 6. Due to the slight fluctuation in room temperature and unsteady flow supply from the blower, instantaneous measurements of temperature rise were averaged over the total 4 hrs. running period to provide the steady state heat contribution and power. A sample calculation is presented in Appendix II and results are given in Table 7. The heat contribution of the blower motor is independent of the friction motor heat output and remained relatively constant for the set-up configuration throughout the test.

## 4.3 Friction motor and drum heat output, steady state motor power and overall thermal performance

The start-up surge current for the 3 hp. friction drum motor was measured to be 133 amperes. The steady state friction motor power was averaged at about 2.53 KW. Typical raw data are shown in Table 8, and reduced data in Table 9.

The friction heat portion of the furnace was found to have 98% efficiency, while the furnace overall thermal efficiency, taking into account the blower motor, was 93%. In a normal house heating situation, where all the blower power is ultimately dissipated as heat, the overall efficiency of the furnace would be more typically represented by the 98% figure. The measured overall power and efficiencies are given in Table 10.

| TIME | Electrical meter Readings, Kwh | Inlet Air Temp., °C | Outlet Air Temp., °C | | | | | Room Temperature, °C |
|---|---|---|---|---|---|---|---|---|
| 10:45 | 228.4 | 22.0 | 23.1 | 23.1 | 23.1 | 23.1 | 23.3 | 20.7 |
| 11:00 | | 22.2 | 23.7 | 23.7 | 23.8 | 23.7 | 23.8 | 20.7 |
| 11:15 | | 21.1 | 23.4 | 23.4 | 23.5 | 23.4 | 23.5 | 20.8 |
| 11:30 | | 22.5 | 24.0 | 24.0 | 24.0 | 24.0 | 24.1 | 21.1 |
| 11:45 | | 22.3 | 24.0 | 24.0 | 24.0 | 24.0 | 24.1 | 21.2 |
| 12:00 | | 21.2 | 23.4 | 23.4 | 23.5 | 23.5 | 23.5 | 20.6 |
| 12:15 | | 22.4 | 24.2 | 24.2 | 24.2 | 24.2 | 24.3 | 21.2 |
| 12:30 | | 22.0 | 24.2 | 24.2 | 24.2 | 24.2 | 24.3 | 21.0 |
| 12:45 | | 22.7 | 24.4 | 24.4 | 24.5 | 24.5 | 24.6 | 20.9 |
| 13:00 | | 22.3 | 24.4 | 24.3 | 24.4 | 24.4 | 24.5 | 21.1 |
| 13:15 | | 23.1 | 24.8 | 24.8 | 24.8 | 24.8 | 24.9 | 21.2 |
| 13:30 | | 22.5 | 24.6 | 24.6 | 24.7 | 24.7 | 24.7 | 21.3 |
| 13:45 | | 23.5 | 25.3 | 25.3 | 25.3 | 25.3 | 25.4 | 21.8 |
| 14:00 | | 23.2 | 25.2 | 25.2 | 25.3 | 25.3 | 25.3 | 21.5 |
| 14:15 | | 22.9 | 24.9 | 24.9 | 25.0 | 25.0 | 25.0 | 21.4 |
| 14:30 | | 23.8 | 25.5 | 25.4 | 25.5 | 25.5 | 25.5 | 22.0 |
| 14:45 | | 23.4 | 25.5 | 25.5 | 25.5 | 25.5 | 25.6 | 21.7 |
| 14:50 | 230.0 | | | | | | | |

Table 6. BLOWER MOTOR HEAT CONTRIBUTION AND STEADY STATE MOTOR POWER RAW DATA.

| Ave. inlet air temp. °C | Ave. outlet air temp. °C | Heat contribution BTU/hr. (KW) | Steady state power BTU/hr. (KW) |
|---|---|---|---|
| 22.54 | 24.39 | 852.11 (.25) | 1338.29 (.392) |

Table 7. REDUCED DATA AND RESULTS FOR BLOWER MOTOR HEAT CONTRIBUTION AND STEADY STATE MOTOR POWER

Table 8. RAW DATA FOR FRICTION MOTOR AND DRUM HEAT OUTPUT AND STEADY STATE MOTOR POWER

| TIME | Electrical meter Readings, Kwh | Inlet Air Temp., °C | Outlet Air Temp., °C | | | | | Room Temperature, °C |
|---|---|---|---|---|---|---|---|---|
| 07:55 | 282.8 | 21.9 | 42.2 | 42.2 | 42.7 | 43.2 | 43.3 | 21.1 |
| 08:00 | | 21.6 | 42.1 | 42.2 | 42.5 | 43.0 | 43.1 | 21.1 |
| 08:05 | | 22.3 | 42.0 | 41.9 | 42.5 | 43.1 | 43.2 | 21.0 |
| 08:10 | | 22.7 | 42.5 | 42.5 | 43.0 | 43.5 | 43.5 | 21.5 |
| 08:15 | | 24.1 | 43.2 | 43.4 | 43.6 | 44.1 | 44.2 | 21.7 |
| 08:20 | | 24.4 | 43.4 | 43.7 | 43.9 | 44.4 | 44.5 | 21.9 |
| 08:25 | | 24.5 | 43.9 | 43.9 | 44.3 | 44.9 | 44.8 | 21.8 |
| 08:30 | | 24.4 | 44.1 | 44.0 | 44.5 | 45.0 | 45.0 | 22.1 |
| 08:35 | | 24.1 | 43.9 | 44.1 | 44.3 | 44.8 | 44.7 | 21.8 |
| 08:40 | | 24.0 | 43.8 | 43.6 | 44.2 | 44.8 | 45.0 | 21.9 |
| 08:45 | | 23.6 | 43.6 | 43.6 | 44.1 | 44.6 | 44.6 | 21.9 |
| 08:50 | | 24.2 | 44.0 | 43.8 | 44.3 | 44.8 | 44.9 | 22.0 |
| 08:55 | | 24.1 | 44.1 | 44.2 | 44.6 | 45.2 | 45.0 | 22.3 |
| 09:00 | | 24.9 | 44.6 | 44.4 | 45.0 | 45.5 | 45.6 | 22.3 |
| 09:05 | | 24.9 | 44.7 | 44.8 | 45.1 | 45.5 | 45.6 | 22.3 |
| 09:10 | | 24.8 | 44.7 | 45.0 | 44.9 | 45.5 | 45.5 | 22.3 |
| 09:15 | | 23.7 | 44.1 | 44.2 | 44.4 | 45.0 | 45.0 | 22.1 |
| 09:20 | | 23.9 | 44.0 | 44.2 | 44.4 | 44.9 | 44.9 | 22.1 |
| 09:25 | | 23.6 | 43.9 | 43.8 | 44.2 | 44.8 | 44.9 | 22.1 |
| 09:30 | | 23.7 | 43.8 | 43.8 | 44.1 | 44.7 | 44.8 | 22.1 |
| 09:35 | | 24.7 | 44.2 | 44.0 | 44.6 | 45.1 | 45.2 | 22.3 |
| 09:40 | | 25.0 | 44.3 | 44.5 | 44.9 | 45.4 | 45.3 | 22.5 |
| 09:45 | | 24.2 | 44.2 | 44.1 | 44.7 | 45.3 | 45.2 | 22.3 |
| 09:50 | | 24.4 | 44.3 | 44.6 | 44.8 | 45.3 | 45.2 | 22.4 |
| 09:55 | | 24.9 | 44.4 | 44.3 | 45.0 | 45.5 | 45.5 | 22.4 |

Table 8. (Continued)

| TIME | Electrical meter Readings, Kwh | Inlet Air Temp., °C | Outlet Air Temp., °C | | | | | Room Temperature, °C |
|---|---|---|---|---|---|---|---|---|
| 10:00 | | 24.3 | 44.3 | 44.0 | 44.6 | 45.2 | 45.4 | 22.2 |
| 10:05 | | 24.3 | 44.2 | 44.1 | 44.6 | 45.1 | 45.3 | 22.2 |
| 10:10 | | 24.5 | 44.2 | 44.1 | 44.6 | 45.0 | 45.1 | 22.1 |
| 10:15 | | 24.6 | 44.3 | 44.1 | 44.9 | 45.4 | 45.3 | 22.1 |
| 10:20 | | 25.1 | 44.7 | 44.9 | 45.0 | 45.5 | 45.4 | 22.5 |
| 10:25 | | 25.0 | 44.5 | 44.3 | 45.1 | 45.6 | 45.6 | 22.5 |
| 10:30 | | 25.2 | 44.8 | 44.9 | 45.0 | 45.6 | 45.6 | 22.7 |
| 10:35 | | 25.0 | 44.8 | 44.9 | 45.0 | 45.7 | 45.7 | 23.0 |
| 10:40 | | 24.2 | 44.6 | 44.5 | 45.1 | 45.5 | 45.5 | 23.4 |
| 10:45 | | 24.4 | 44.6 | 44.8 | 44.9 | 45.6 | 45.5 | 22.8 |
| 10:50 | | 24.1 | 44.2 | 44.1 | 44.6 | 45.2 | 45.1 | 22.2 |
| 10:55 | | 24.2 | 44.1 | 44.1 | 44.4 | 44.9 | 44.9 | 22.5 |
| 11:00 | | 24.1 | 44.1 | 43.8 | 44.4 | 44.9 | 44.9 | 22.6 |
| 11:05 | | 24.5 | 44.1 | 44.2 | 44.8 | 45.3 | 45.2 | 22.5 |
| 11:10 | | 24.7 | 44.2 | 44.1 | 44.7 | 45.2 | 45.3 | 22.5 |
| 11:15 | | 24.9 | 44.4 | 44.5 | 44.8 | 45.3 | 45.1 | 22.7 |
| 11:20 | | 24.9 | 44.6 | 44.4 | 44.9 | 45.4 | 45.4 | 22.4 |
| 11:25 | | 25.5 | 44.8 | 44.9 | 45.2 | 45.5 | 45.4 | 22.3 |
| 11:30 | | 24.4 | 44.3 | 44.4 | 44.8 | 45.3 | 45.2 | 22.2 |
| 11:35 | | 24.8 | 44.5 | 44.2 | 44.8 | 45.3 | 45.4 | 22.2 |
| 11:40 | | 24.5 | 44.2 | 44.1 | 44.7 | 45.1 | 45.2 | 22.2 |
| 11:45 | | 23.9 | 43.9 | 44.1 | 44.4 | 44.8 | 44.8 | 22.7 |
| 11:50 | | 24.0 | 43.8 | 44.0 | 44.5 | 44.8 | 44.8 | 22.3 |
| 11:55 | 294.5 | 24.8 | 44.1 | 43.9 | 44.6 | 45.1 | 45.2 | 22.7 |

Table 9. REDUCED DATA FOR FRICTION MOTOR AND DRUM HEAT OUTPUT

| TIME | Inlet Air Temp. °C | Average Outlet Air Temp, °C | Average Temp Rise °C | Net Heat Output $\dot{Q}_{net}$, BTU/hr (KH) |
|---|---|---|---|---|
| 07:55 | 21.9 | 42.72 | 20.82 | 8737.55 (2.56) |
| 08:00 | 21.6 | 42.58 | 20.98 | 8811.24 (2.58) |
| 08:05 | 22.3 | 42.54 | 20.24 | 8470.40 (2.48) |
| 08:10 | 22.7 | 43.00 | 20.30 | 8498.04 (2.49) |
| 08:15 | 24.1 | 43.70 | 19.60 | 8175.62 (2.39) |
| 08:20 | 24.4 | 43.98 | 19.58 | 8166.41 (2.39) |
| 08:25 | 24.5 | 44.36 | 19.86 | 8295.37 (2.43) |
| 08:30 | 24.4 | 44.52 | 20.12 | 8415.13 (2.46) |
| 08:35 | 24.1 | 44.36 | 20.26 | 8479.61 (2.48) |
| 08:40 | 24.0 | 44.28 | 20.28 | 8488.83 (2.49) |
| 08:45 | 23.6 | 44.10 | 20.50 | 8590.16 (2.52) |
| 08:50 | 24.2 | 44.36 | 20.16 | 8433.55 (2.47) |
| 08:55 | 24.1 | 44.62 | 20.52 | 8509.37 (2.52) |
| 09:00 | 24.9 | 45.02 | 20.12 | 8415.13 (2.46) |
| 09:05 | 24.9 | 45.14 | 20.24 | 8470.40 (2.48) |
| 09:10 | 24.8 | 45.12 | 20.32 | 8507.25 (2.49) |
| 09:15 | 23.7 | 44.54 | 20.84 | 8746.76 (2.56) |
| 09:20 | 23.9 | 44.48 | 20.58 | 8627.01 (2.53) |
| 09:25 | 23.6 | 44.32 | 20.72 | 8691.49 (2.55) |
| 09:30 | 23.7 | 44.24 | 20.54 | 8608.58 (2.52) |
| 09:35 | 24.7 | 44.62 | 19.92 | 8323.01 (2.44) |
| 09:40 | 25.0 | 44.88 | 19.88 | 8304.59 (2.43) |
| 09:45 | 24.2 | 44.70 | 20.50 | 8590.16 (2.52) |
| 09:50 | 24.4 | 44.84 | 20.44 | 8562.52 (2.51) |
| 09:55 | 24.9 | 44.94 | 20.04 | 8378.28 (2.45) |

Table 9. (Continued)

| TIME | Inlet Air Temp. °C | Average Outlet Air Temp, °C | Average Temp Rise °C | Net Heat Output $Q_{net}$, BTU/hr (KW) |
|---|---|---|---|---|
| 10:00 | 24.3 | 44.70 | 20.40 | 8544.10 (2.50) |
| 10:05 | 24.3 | 44.66 | 20.36 | 8525.67 (2.50) |
| 10:10 | 24.5 | 44.60 | 20.10 | 8405.92 (2.46) |
| 10:15 | 24.6 | 44.80 | 20.20 | 8451.98 (2.48) |
| 10:20 | 25.1 | 45.10 | 20.00 | 8359.86 (2.45) |
| 10:25 | 25.0 | 45.02 | 20.02 | 8369.07 (2.45) |
| 10:30 | 25.2 | 45.18 | 19.98 | 8350.65 (2.45) |
| 10:35 | 25.0 | 45.22 | 20.22 | 8461.19 (2.48) |
| 10:40 | 24.2 | 45.04 | 20.84 | 8746.76 (2.56) |
| 10:45 | 24.4 | 45.08 | 20.68 | 8673.06 (2.54) |
| 10:50 | 24.1 | 44.64 | 20.54 | 8608.58 (2.52) |
| 10:55 | 24.2 | 44.48 | 20.28 | 8488.83 (2.49) |
| 11:00 | 24.1 | 44.42 | 20.32 | 8507.25 (2.49) |
| 11:05 | 25.4 | 44.72 | 20.22 | 8461.19 (2.48) |
| 11:10 | 24.7 | 44.70 | 20.00 | 8359.86 (2.45) |
| 11:15 | 24.9 | 44.82 | 19.92 | 8323.01 (2.44) |
| 11:20 | 24.9 | 44.94 | 20.04 | 8378.28 (2.45) |
| 11:25 | 25.5 | 45.16 | 19.66 | 8203.25 (2.40) |
| 11:30 | 24.4 | 44.80 | 20.40 | 8544.10 (2.50) |
| 11:35 | 24.8 | 44.84 | 20.04 | 8378.28 (2.45) |
| 11:40 | 24.5 | 44.66 | 20.16 | 8433.55 (2.47) |
| 11:45 | 23.9 | 44.40 | 20.50 | 8590.16 (2.52) |
| 11:50 | 24.0 | 44.38 | 20.38 | 8534.89 (2.50) |
| 11:55 | 24.8 | 44.58 | 19.78 | 8258.53 (2.42) |

| Average Gross heat output rate BTU/hr, (KW) | Average Energy input rate BTU/hr, (KW) | Average Friction heat output rate BTU/hr, (KW) | Average Friction energy input rate BTU/hr, (KW) | Friction Heat Efficiency | Overall Furnace Efficiency |
|---|---|---|---|---|---|
| 9328.53 (2.73) | 10003.02 (2.93) | 8476.42 (2.48) | 8637.42 (2.53) | .98 | .93 |

Table 10. RESULTS FOR FRICTION MOTOR AND DRUM THERMAL PERFORMANCE AND FURNACE OVERALL THERMAL EFFICIENCY

5.1 The estimated accuracy of the tests on the friction furnace is ±5% - most of which can be attributed to the inaccuracies of flow measurement. The overall thermal efficiency of the furnace was found to be 93% ±5% under test conditions. These conditions differ slightly from typical residential heating conditions, in that not all the blower power is dissipated as heat within the test system.

5.2 In a typical residential heating situation, where all the blower power will ultimately be dissipated as heat, the overall efficiency of the furnace will be 98%, subject to the same experimental error of ±5%.

5.3 The furnace has a heating capacity of 8,500 Btu/h (2.49 KW) based on frictional heating alone (ie excluding the amount contributed by the blower). A moderately energy-efficient house in Saskatchewan, conforming approximately to the NRC "Measures", requires a heating capacity of typically 40,000 to 45,000 Btu/h (11.7 - 13.2 KW). A super energy-efficient house requires a heating capacity of typically 25,000 - 30,000 Btu/h (7.3 - 8.8 KW). The tested furnace is therefore considerably undersized for all conceivable residential heating applications in a Saskatchewan-type climate.

5.4 The tests have shown that this particular design of friction furnace has an efficiency of 98%, subject to an experimental error of ±5%. Therefore, it would not be unreasonable for the manufacturer to claim a 100% efficiency for his product. Normally, electrical heating appliances rely on the resistance heating effect - examples of this are the electrical baseboard heater and the conventional electrical furnace. These have a well-established efficiency rating of 100% - or as close as makes no real difference. Therefore, in terms of efficiency, there is nothing to be gained by using the friction furnace rather than the more conventional methods of electrical heating. In terms of operational problems, the friction furnace has more moving parts than conventional electrical heating systems, and its mode of operation is conducive to wear of these parts. Also, the friction furnace generates a large current surge whenever the main motor is started up. This was a problem even with the low capacity unit that was tested. A more appropriately-sized unit, in a typical residential application, would involve some specialized electrical supply requirements.

5.5 The tests have shown that this particular design of friction furnace performs in accordance with the laws of thermodynamics - as it should. These laws state that, in this situation, one form of energy cannot be converted into another (eg. electricity into heat) with an efficiency that is greater than 100%. There is sometimes a misconception that, with a little bit of ingenuity, these laws can be broken. This is not so; the law is an expression of a basic natural principle.

5.6 There are several different friction furnace models, made by different manufacturers. These tests have been conducted on only one model, and, properly speaking, the conclusions apply only to that model. But, since this is a matter of considerable public interest, it has been thought advisable to comment on the performance of other models. All the friction furnace models work on the same principle: the use of electrical power to generate heat by friction. The design details may vary, but the essential process is the same. The tests have shown that this process obeys the natural principles of thermodynamics, and has an efficiency that is consistent with the 100% limit imposed by these principles. This finding can be extrapolated to all other frictional furnaces, with no loss of scientific rigour. It is therefore concluded that all friction furnaces have a real overall efficiency of 100% or slightly less.

Sample calculation for air flow rate

Average inlet air velocity head:

$$\left(\frac{\sqrt{.070} + \sqrt{.092} + \sqrt{.110} + \sqrt{.094} + \sqrt{.092} + \sqrt{.072}}{6}\right)^2$$

= .088 in. of water

Average inlet air velocity:

$1096.5\sqrt{(hw\rho)}$ fpm.

$= 1096.5\sqrt{.088/.0748}$ fpm.

= 1189.3 fpm.

Average inlet air flow rate:

$\frac{\pi D^2}{4}$ x 1189.3 CFM

$= \frac{\pi (6/12)^2}{4}$ x 1189.3 CFM

= 233.5 CFM

Mass flow rate:

$233.5 \times \rho$ lb/min.

= 233.5 x .0748 lb/min.

= 17.47 lb/min.

Sample calculation for blower motor heat contribution and steady state motor power

Average inlet air temperature:

$$\frac{22.0 + 22.2 + 21.2 + 22.5 + 22.3 + 21.2 + 22.4 + .....}{17}$$

$= 22.54^{o}C$

Average outlet air temperature:

$$\frac{23.1 + 23.7 + 23.4 + 24.0 + 24.0 + 23.4 + 24.2 + .....}{17}$$

$= 24.39$

Average temperature rise, $\Delta T$:

$(24.39 - 22.54)^{o}C$

$= 1.85^{o}C$

Mass flow rate of air, $\dot{M}$:

17.77 lb/min.

Specific heat of air at constant pressure, Cp:

.24 $BTU/lb^{o}F$

Heat contribution by blower motor:

$\dot{M}$ Cp $\Delta T$

$= 17.77 \times .24 \times 1.85 \times \frac{9}{5}$

$= 14.20\ BTU/min.$

$= 852.11\ BTU/min.$

Steady state motor power:

$(230.0 - 228.4)$ Kwh $(4 + \frac{5}{60})$ hr.

$= .395$ Kwh/hr.

$= 395$ WATTS

Sample calculation for friction motor and drum heat output, steady state motor power and overall thermal efficiency

Gross heat output, $\dot{Q}_g = \dot{M}\ Cp\ \Delta T$

$= 17.77\ ^{lb}/_{min.} \times .24\ ^{BTU}/_{11^oF} \times 20.00(\frac{9}{5})\ ^oF$

$= 153.53$ BTU/min.

$= 9211.97$ BTU/hr.

Net heat output rate, $\dot{Q}_{net} = \dot{Q}_a - \dot{Q}_b$

$= (9211.97 - 852.11)$ BTU/hr.

$= 8359.86$ BTU/hr.

Total energy input rate, $\dot{Q}_{in} = (Kwh_2 - Kwh_1)/\Delta hr.$

$= (294.5 - 282.2)/4$ Kw

$= 2.93$ Kw

Net energy input rate, $\dot{Q}_{\lambda}$ $(2.93 - .4)$ Kw

or steady state motor power $= 2.53$ Kw

$= 8638.43$ BTU/hr.

Efficiency of friction heat, $N = \frac{\dot{Q}_{net}}{\dot{Q}_{\lambda}}$

$= \frac{8359.86}{8638.43}$

$= .97\ (97\%)$

Overall efficiency of friction furnace:

$\frac{\text{Gross heat output rate}}{\text{Total energy input rate}} = \frac{\dot{Q}_g}{\dot{Q}_{in}}$

$= \frac{9328.53}{2.93 \times 3414}$

$= .93$

$= 93\%$

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